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Response of Two Different Strains of Commercial Broilers to Different Dietary Amino Acid Allowance

B. Indarsih*
Jurusan Produksi Ternak, Fakultas Peternakan, Universitas Mataram
Jln. Majapahit No. 62 Mataram Lombok Nusa Tenggara Barat
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ABSTRACT

The response of Cobb and Ingham strain commercial broilers to a range of dietary amino acids in a factorial experiment (2 strains x 2 sexes x 3 dietary treatments) with 3 replicates was evaluated. A total of 180 birds was sexed and weighed at one-day-old and randomly distributed to 36 brooders. Summit (246 g CP and 16.8 g lysine/kg) and dilution (120 g CP and 6.0 g lysine/kg) diets were prepared in isocaloric at 3100 kcal ME/kg. The estimated dietary level of crude protein for all birds at day-old was 240 g/kg and at 42 days were 120, 140 or 160 g/kg for females or 140, 160 or 180 g/kg for males. Body composition was measured at 42 days. Results revealed that strain Cobb males and females had a higher daily intake than Ingham, but Cobb females were less efficient in converting feed to weight gain than that of Ingham. The quantitative differences did not exist between genotypes, crude protein and lysine. Daily gain and feed utilization efficiency in both sexes were highest in group receiving the high protein diet. Lysine requirement was 14.58 g lysine /kg diet and 12.96 g/kg higher than NRC recommendation (1.05 % or 10.5 g/kg) for maximum breast meat and lowest abdominal fat.

Key words: lysine, summit, dilution, breast meat, abdominal fat

INTRODUCTION

Considerable research exists looking at dietary needs of the most limiting essential amino acids (Koch *et al*., 2002; Oviedo-Rondón & Waldroup, 2002; Sterling *et al*., 2003; Furlan *et al*., 2004; Dozier *et al*., 2008ab). Differences in growth rate and carcass composition between and among strains of broilers have also been observed for many years (Ten Doeschate *et al*., l993; Sterling *et al.,* 2006). The most limiting amino acid requirement particularly lysine in different strains has been shown to be greater for maximal feed efficiency than for maximal growth (Fatufe *et al.,* 2004; Sterling *et al.,* 2006). NRC (1994) requirement for lysine for broilers 3-6 wk of age is 1.00% total. Reported by Dirain & Waldroup (2002) that increasing lysine levels from 1.03% to 1.12% significantly (P<0.05) improved breast yield (BY) and reduced abdominal fat. Although estimated requirement for limiting amino acids vary, it is agreed that requirement for growth is less than

*Korespondensi:
Jurusan Produksi Ternak, Fakultas Peternakan,
Universitas Mataram
Jln. Majapahit No. 62 Mataram Lombok Nusa Tenggara Barat
E-mail: iintjipto@gmail.com

that for feed conversion and meat yield. In addition, increase in the levels of these amino acids individually or in combination with other factors (crude protein, essential amino acids, and energy) results in better growth and meat yield (de Leon, 2006).

When supply of essential amino acids is limiting but dietary energy concentration is high, the feed consumption is an increase in an attempt to satisfy essential amino acid (EAA) requirement (Koch *et al*, 2002; Oviedo-Rondón & Waldroup, 2002. Dirain & Waldroup, 2002; de Leon, 2006). In this circumstance, intake is largely regulated by EAA requirement and growth is limited by amino acid intake. In commercial practice, formulating diets to fulfil minimums amino acid is critical to optimize live production and breast meat yield of broiler chicken. Therefore, this study was undertaken to evaluate the growth response of two different commercial broiler genotypes (Cobb and Ingham) to a range of dietary amino acid regimens.

MATERIALS AND METHODS

Birds and Experimental Procedure

Cobb and Ingham (n=90 per genotype) broiler chicks of commercial strains were randomized and reared in 36 bamboo brooder cage of 1.0 m x 1.0 m each to investigate the response in growth and body composition to a range of dietary amino acid regimens. The chicken were sexed and weighed at one day old and alocated in to 3 dietary treatments with 3 replicates of 5 birds each. Each cage was equipped with one drinker and 1 circular tube feeder. Temperature of the experimental house was maintained at about 32 °C for week 1, 29 °C for week 2, 26 °C for week 3, and 22 °C thereafter. Birds and feed were weighed on a weekly basis. At 42 days of age, all samples of 5 birds from each dietary treatment were slaughtered for measurement of body composition. Breast meat and abdominal fat were removed and weighed.

Dietary Treatments and Feeding Programs

A summit-dilution approach was used in many of the studies in diet formulation to examine the growth and body composition responses of different genotypes to variation in dietary amino acid concentration (Gous & Morris, l985; Surisdiarto & Farrell, l991; Huyghebaert & Pack, l996; Plumstead *et al.*, 2007). The summit diet was formulated to contain a large excess of assume requirement of all indispensable amino acids except the one

Table 1. Ingredient and determined nutrient composition of the summit and dilution diets used in this experiment

	Summit	Dilution
Ingredients (g/kg)		
Sorghum	308.90	551.60
Wheat	300.00	311.70
Soybean oil	21.70	20.00
Limestone	8.92	8.87
Salt	1.26	2.59
Soybean meal	250.80	30.8
Fishmeal	70.00	-
Meat and bone meal	27.30	37.40
Rice hulls	0.00	20.00
Dicalcium phosphate		7.60
DL-Methionine	0.50	0.14
Lysine Mono-HCL	4.00	2.70
Vitamins and minerals	6.68	6.68
Nutrients (g/kg)		
ME (kcal/kg)*	3100.00	3100.00
Crude Protein	246.50	120.00
Lysine (total)	16.80	6.00
Methionine	5.60	2.10
Methionine plus cystine	10.04	4.92
Isoleucine	12.21	5.17
Leucine	21.07	12.11
Threonine	10.06	4.20
Tryptophan	3.20	1.35
Calcium	10.00	10.00
Phosphorus (available)	4.50	4.50

*ME=metabolizable energy; calculated values.

Table 2. The calculated range in lysine and methionine (g/kg) in each dietary regimen from day old to 42 days of age

Sex	Protein level	Lysine	Methionine
Male	LP-140	16.0-8.5	5.4-2.9
	MP-160	16.2-10.0	5.4-3.4
	HP-180	16.3-11.6	5.4-3.9
Female	LP-120	15.9-6.9	5.3-2.4
	MP-140	16.0-8.5	5.4-2.9
	HP-160	16.2-10.0	5.4-3.4

For male: LP-140=low protein (140 g/kg), MP-160=medium protein (160 g/kg), HP-180=high protein (180 g/kg); for female: LP-120=low protein (120 g/kg), MP-140=medium protein (140 g/kg), HP-160=high protein (160 g/kg).

under test, which was set at around 145% of assume requirement (Gous & Morris, l985)

Summit (246 g crude protein/CP and 16.8 g lysine/kg) and dilution (120 g CP and 6.0 g lysine/kg) diets were prepared (Table 1) in isocaloric approximately 3100 kcal ME/kg. Birds in each sex were given one of three dietary regimens with dietary change every 7 days. The estimated dietary level of crude protein for all birds at day-old was 240 g/kg and the level at 42 days was 120, 140, or 160 g/kg for females or 140, 160, and 180 g/kg for males. With weekly change in diets, the protein level in the diet provided was calculated at the midpoint for each 7-day period and was achieved by blending appropriate amounts of the summit and dilution diet.

Statistical Analysis

Data were analyzed by ANOVA (analysis of variance) (Steel & Torrie, 1980). The major independent variables were genotype, sex and diet. Least significant difference (LSD) multiple range tests (probability $P<0.05$) identified all results showing a significant difference, unless otherwise stated (Kaps & Lamberson, 2004).

RESULTS AND DISCUSSION

Growth Responses

The first step in evaluating an amino acid requirement is to develop a diet that is limiting only in the amino acid that is of interest. The experimental diets here were clearly not deficient in lysine as indicated by the not significant responses on feed intake for both sexes and strains (Table 3). Birds fed the diet containing protein 140 g/kg at 42 days (low protein diet) and 160 g/kg (medium protein diet) had body weight gain (47.1 g/bird/day and 47.4 g/bird/day) and feed/gain ratio (1.979 and 1.909) that were lower than responses of body weight gain (49.9 g/bird/day) and feed/gain ratio (1.814) of birds receiving 180 g/kg (high protein diet) in males. Similar trend was also shown in females.

Lysine and methionine intake increased on low dietary protein and decreased on high dietary protein (Table 4). Thus, feed intake was regulated by amino acid requirement. Therefore, improvement in body weight gain and feed/gain ratio can be made on a dietary amino acids with a high density.

In regard to feed intake, Cobb males and females had a higher daily intake than Ingham birds ($P>0.05$). However, Ingham had a better feed conversion ratio (FCR) when compared with Cobb in both sexes. Daily gain and feed utilization efficiency in both sexes were highest in groups receiving the high protein dietary regimens. There was, however, no significant effect in either sex on gain or FCR of increasing the dietary amino acid allowance from the low to the medium protein dietary regimens. Feed intake in the males given composite diets was greatest on the low L-140 dietary regimen and in the females was greatest in the birds given the high protein H-160 dietary regimen. In both sexes, there was a linear decrease in FCR with increase in dietary protein, although in the females the difference between dietary regimens was not significant for LP-120 and MP-140 and was significant for HP-160 dietary regimen. This is in agreement to Nikolova

Table 3. Gain (g/d), food intake (FI, g/d) and feed conversion ratio (FCR) of two sexes broilers from hatch to 43 days of age affected by different strain and dietary regimen

Variable	Male			Variable	Female		
	Gain	FI	FCR		Gain	FI	FCR
Strain				Strain			
Cobb	48.40	91.0	1.918	Cobb	40.80	83.6	2.052[a]
Ingham	47.90	88.0	1.884	Ingham	40.90	82.0	2.010[b]
LSD 0.05	1.51	3.3	0.048	LSD 0.05	0.81	1.7	0.021
Diet				Diet			
LP-140	47.10[b]	91.0	1.979[A]	LP-120	41.80[B]	82.5	2.073[A]
MP-160	47.40[b]	88.0	1.909[B]	MP-140	41.90[B]	82.2	2.058[A]
HP-180	49.90[a]	89.0	1.814[C]	HP-160	43.80[A]	83.8	1.960[B]
LSD 0.05	1.84	4.0	0.056	LSD 0.05	0.98	1.9	0.026
Strain	NS	NS	NS	Strain	NS	NS	*
Diet	*	NS	**	Diet	**	NS	**
Strain x Diet	NS	NS	NS	Strain x Diet	NS	NS	NS

*(P<0.05); **(P<0.01); NS=not significant (P>0.05); means within columns with no common superscript differ significantly (P<0.05); For male: LP-140=low protein (140 g/kg), MP-160=medium protein (160 g/kg), HP-180=high protein (180 g/kg); for female: LP-120=low protein (120 g/kg), MP-140=medium protein (140 g/kg), HP-160=high protein (160 g/kg).

et al. (2007), Corzo *et al.* (2006) that female broilers did not respond to dietary lysine for any variable measured.

In this experiment the improvement in feed utilization efficiency in the higher dietary protein regimens (Table 3) was generally associated with an increase in growth rate, with variable effects on feed intake. These result agree with Dirain & Waldroup (2002), Koch *et al.* (2002), Araújo *et al.* (2004), Corzo *et al.* (2005); Dozier *et al.* (2008ab) who noted increasing dietary CP and lysine levels significantly improved BWG (body weight gain) and FCR.

Carcass Responses

Carcass traits of 42-day-old broilers as affected by total dietary lysine and methionine appear in Table 4 and 5. Breast meat weight improved (P<0.01) as dietary protein and lysine increased but significant reduction in fat pad weight and percentage fat pad. These results agree with Koch *et al.* (2002), Fatufe *et al.* (2004), Corzo & Kidd (2004), Corzo *et al.* (2005) and Moritz *et al.* (2005) that the level of lysine needed to minimize abdominal fat may be below that.

In both sexes, strain Cobb birds had both higher breast meat yield and abdominal fat than strain Ingham. For the males and females, there was linear across-strain increase in breast meat yield with increase in dietary protein and in the males, a decrease in abdominal fat with increasing dietary protein. In the females, there was a decrease in fatness from the low to the medium protein dietary regimen, but no further decrease to the high protein regimen. (Table 6). In males, strain Cobb appeared to have a higher breast meat yield than of strain Ingham (Table 4) and a lower proportion of abdominal fat than females, but direct comparison was not possible due to different dietary regimens in the two sexes.

The significantly higher breast yield and abdominal fat in strain Cobb than in strain Ingham (Table 5) illustrated that these two traits are not necessarily negatively correlated,

Table 4. Lysine and methionine intake (g/d) of two sexes broilers from day old to 42 days of age affected by different strain and dietary regimens

Sex	Protein level	Lysine	Methionine
Male	LP-140	0.582*	6,097
	MP-160	0.563	5,896
	HP-180	0.570	5,963
Female	LP-120	0.528	5,528
	MP-140	0.526	5,507
	HP-160	0,536	5,615

*Calculated values; For male: LP-140=low protein (140 g/kg), MP-160=medium protein (160 g/kg), HP-180=high protein (180 g/kg); for female: LP-120=low protein (120 g/kg), MP-140=medium protein (140 g/kg), HP-160=high protein (160 g/kg).

but that, as suggested by Rosa *et al*. (2001ab) there is not a strong antagonism between protein deposition and fat deposition, particularly when both are expressed in absolute terms. It would seem that strain Cobb has been effectively selected for breast yield but that either because of correlated response or due to high levels of fat in the founder populations; these birds also have high levels of body fat. It is possible that total protein deposition may not necessarily be reflected in breast muscle deposition, and there may be some compensatory response in reduced protein deposition elsewhere in the body. This, however, was not evaluated in the study.

In this experiment in the two sexes, high protein intake obtained from 180 g/kg (18% protein) for males or 160 g/kg (16%) for females produced more breast yield than the lower intake from the lower dietary protein. The increase in breast yield with increasing in dietary protein is in keeping with most reported studies (eg. Koch *et al.,* 2002; Corzo & Kidd, 2004, Corzo *et al.,* 2005). Lysine and the sulfur amino acids (SAA), are known to exhibit specific effects on carcass composition. The decreased fat deposition with increased dietary protein (Table 5 and 6) is also in agreement with the well accepted negative relationship

Table 5. Breast portion (g/kg) and abdominal fat pad (g/kg) of two sexes broilers from hatch to 43 days of age given three dietary amino acid regimens

Variable	Male		Variable	Female	
	Breast meat	Abdominal fat		Breast meat	Abdominal fat
Strain			Strain		
Cobb	154.6^{a}	19.5^{a}	Cobb	158.7^{a}	26.4^{a}
Ingham	143.7^{b}	12.7^{b}	Ingham	145.9^{b}	19.0^{b}
Diet			Diet		
LP-140	143.9^{c}	19.0^{a}	LP-120	142.8^{c}	25.5^{a}
MP-160	149.1^{b}	16.3^{b}	MP-140	151.0^{b}	21.6^{b}
HP-180	154.4^{a}	12.9^{c}	HP-160	163.2^{a}	21.0^{b}
Pooled			Pooled		
SEM	2.80	0.94	SEM	2.97	1.31
Strain	***	***	Strain	***	***
Diet	**	***	Diet	**	***
Strain x diet	NS	NS	Strain x diet	NS	NS

(P<0.01); *(P<0.001); NS=not significant (P>0.05); means within columns with no common superscript differ significantly (P<0.05); For male: LP-140=low protein (140 g/kg), MP-160=medium protein (160 g/kg), HP-180=high protein (180 g/kg); for female: LP-120=low protein (120 g/kg), MP-140=medium protein (140 g/kg), HP-160=high protein (160 g/kg).

between dietary protein and carcass fat (eg. Gous *et al.*, 1990; Leclercq & Beaumont, 2001; Koch *et al.,* 2002; Corzo *et al.,* 2005). The effect here of an increase in breast yield and a decrease in fat deposition has been achieved by a reduction in the dietary concentration of an appropriately balanced diet in terms of amino acid concentration. Supplementation with synthetic amino acids has been shown to give variable results, depending on dietary amino acid balance (Dustin, 2005; Corzo *et al.,* 2006).

In support of the non-significant strain x diet and sex x diet interactions for both traits, in all strain x sex sub groups there was an increase in breast meat yield and a decrease in abdominal fat with increase in dietary protein level. Sibbald & Wolynetz (l986) suggested that the total lysine requirement were about 9.6 g/kg during the starter period. Subsequent studies found 13.9 or 14.4 g lysine/kg diet given to chicks from d 0 to 21 reduced food consumption by 3.5% and reduced gain by 5.3% compared with feeding 13.4 g lysine/kg diet (Latshaw, l993). Gorman & Balnave (1995) reported that commercial broiler chickens required 13.1 and 12.5 g lysine/kg during the starter and finisher phases to achieve maximum breast meat deposition.

Assuming that the digestible lysine is 0.81% (Han & Baker, l993), then the average digestible lysine levels provided were 11.32; 12.96 and 14.58 g/kg diet for the LP, MP and HP regimens respectively in males. Whilst, the average digestible lysine levels 9.72, 11.34, and 12.96 g/kg for LP-MP and HP in females. Thus, in the present study, the 14.58 g lysine/kg diet and 12.96 g/kg gave maximum breast meat and lowest abdominal fat for males and females respectively, regardless of the strains used. This study suggests that, lysine requirement for maximum breast meat yield production in the strain used may be higher than previously suggested. As expected, the protein requirement for breast yield is higher than those required for gain. Some workers suggest that breast meat composition is sensitive to amino acid composition, and that amino acids, other than methionine and lysine of birds my have to be considered (Leeson, 2000; Rosa *et al.,* 2001ab**;** Corzo *et al.*, 2005; Dustin, 2005; Garcia *et al.*, 2006). This means that the 180 g/kg protein for males and 160 g/kg diet for females in this study were formulated to meet

Table 6. Breast meat and abdominal fat (g/kg) of the two strains given three dietary regimens (standard errors in parenthesis)

Strain	Sex	Variable	Breast meat	Abdominal fat
Cobb	Male	LP-140	148.3 (3.2)	22.3 (1.2)
		MP-160	154.4 (2.9)	20.1 (1.0)
		HP-180	161.2 (2.8)	15.9 (0.9)
	Female	LP-120	146.9 (2.8)	29.8 (1.7)
		MP-140	157.4 (3.3)	24.2 (1.2)
		HP-160	171.6 (3.3)	25.1 (1.5)
Ingham	Male	LP-140	139.6 (2.0)	15.7 (0.8)
		MP-160	143.8 (2.4)	12.5 (0.7)
		HP-180	147.7 (2.7)	9.8 (0.6)
	Female	LP-120	138.6 (2.8)	21.1 (0.9)
		MP-140	144.6 (2.3)	18.9 (1.1)
		HP-160	154.7 (2.5)	16.9 (1.0)

For male: LP-140=low protein (140 g/kg), MP-160=medium protein (160 g/kg), HP-180=high protein (180 g/kg); for female: LP-120=low protein (120 g/kg), MP-140=medium protein (140 g/kg), HP-160=high protein (160 g/kg).

all amino acid requirements particularly for developing the breast meat.

Araújo *et al.* (2004) reported protein retention was very closely related to lysine concentration. Thus, improved gains and breast meat yield appear to be due to an adequate supply of lysine (Sterling *et al.,* 2006). Feed intake and feed conversion, respectively, were a function of dietary amino acid level (Koch *et al.,* 2002; Rosa *et al.,* 2001ab; Dozier *et al.,* 2008ab). As shown in Table 1, the level of lysine in the starter diet (240 g/kg) was considerably higher than NRC (1994) suggested requirement so that any response to dietary lysine or other amino acid levels was related more to the levels in the finisher rather than the starter phase. Fatufe *et al.* (2004) and Sterling (2006) found that protein level will affect the responses of different genotypes to dietary lysine differently. This suggested that there is lysine by genotype interaction. In this experiment could detect none (P>0.05).

CONCLUSION

Strain differences in amino acids allowance were apparent although not significant. Cobb broiler chicks gained more and consumed more feed than Ingham but Cobb had a less FCR when compared with Ingham. Male broilers responded to increased dietary amino acid but not in females. In the current study provides evidence that lysine for maximum gain differed from that for maximum breast meat production. Lysine requirement in this experiment the 14.58 g lysine/kg diet and 12.96 g/kg gave maximum breast meat and lowest abdominal fat for males and females respectively, regardless of the strains used. This level was higher than NRC recommendation which is 1.05%. Intake regulation is clearly triggered by the need to fulfill amino acid requirement at maintenance level. Voluntary intake is adjusted when limiting amino acids are deficient or well balanced diet.

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